Exploring age-specific and cumulative cohort rates using Lexis surface lattice plots: An International comparison of Human Fertility Database and Human Fertility Collection Data

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1. Objective

- The aim of this paper is to provide a description of different fertility trends across 45 countries from major geographical regions within and outside Europe.
- Changes in age-specific and cumulative cohort fertility rates are explored by using different visualisation methods of the Lexis surface, such as heat maps and shaded contour plots.

2. Motivation

- In recent decades, fertility patterns across most advanced societies have been characterised by a significant degree of postponement.
- Mean ages at first childbirth rapidly increased to unprecedented levels and this has been linked to the decline of total period fertility.
- Most crucial in this respect is the ensued decrease of fertility to sub-replacement levels.

3. Combining HFD and HFC data

- The Human Fertility Database (HFD) and Human Fertility Collection (HFC) provide a rich source of vital statistics data on births. By combining these data sources, we are able to cover a high number of countries.
- For some countries, combined records from HFD and HFC go back to mid or late 19th century, as in the case of Iceland and Sweden, respectively.

4. Method

- For each country, age-specific fertility rates were arranged to form a Lexis surface, with rows representing different ages and columns representing different years (Lexis, 1875; Vaupel et al., 1987).
- Age-specific fertility rates were visualised as 'heat' maps, by converting the values of age-specific fertility rates at each age-year coordinate to a monochrome shade. This allows the visualisation of a high number of age-specific fertility rates.
- Age-specific fertility rates were subsequently re-arranged by cohorts in order to produce synthetic estimates of cumulative cohort fertility rates for different cohorts.
- These were visualised as shaded contour plots, with each contour line showing the age at which different cohorts achieved selected levels of cumulative fertility (see Minton, 2014; Minton et al. 2013).
- Spatially proximate contour lines indicate steep variations in cumulative cohort fertility rates across the surface.

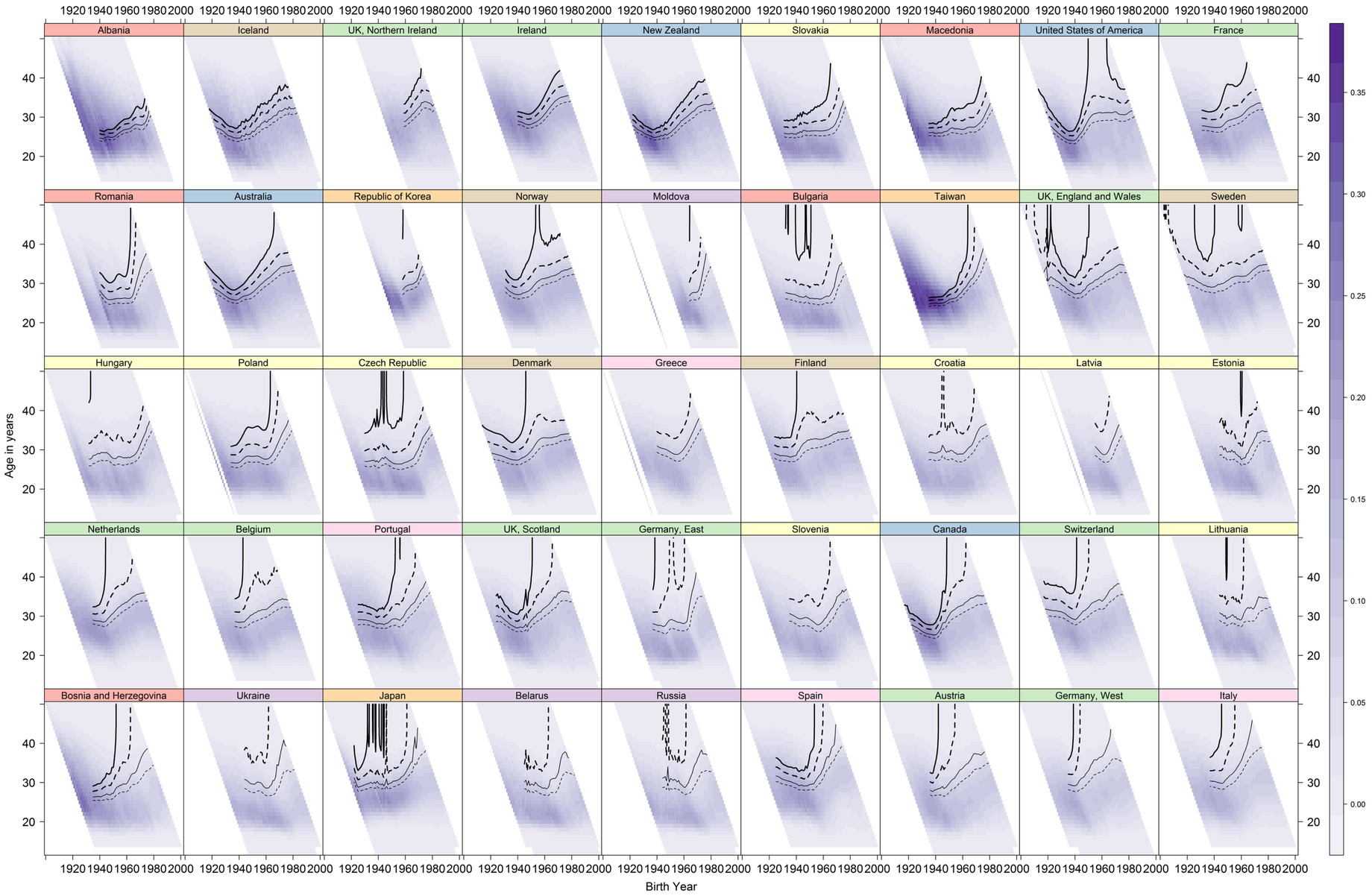
5. Key findings

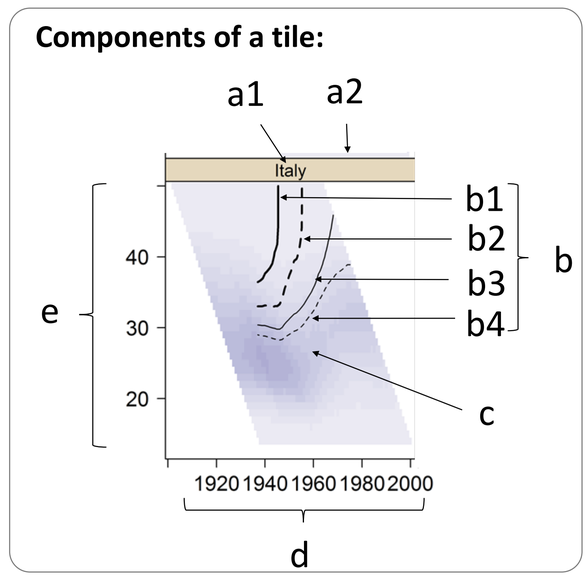
- Figure 1 shows that once countries reach a sub-replacement level, fertility do not revert to prior replacement levels.
- Notable exceptions are the cases of Norway and the USA which revealed rising fertility rates for cohorts born after the 1950s and late 1960s, respectively. This may be linked to changing ethnical composition of the national populations.
- Countries belonging to different geographical regions display a high degree of heterogeneity in cohort fertility. This only partially reflects expected regional differences in fertility trajectories.
- In some countries of Western and Southern Europe, the persistence of fertility levels below 1.5 suggests the need for reliance on international migration to partially offset the demographic deficit that would otherwise emerge.

6. Conclusions

- Complex data visualisations of the Lexis surface reveal a considerable degree of variation in both age-specific and cumulative cohort fertility rates across geographical regions.
- Existing differences in fertility patterns between countries appear to reflect heterogeneity in the socio-economic, political and cultural contexts, suggesting different paths for the achievement of replacement fertility in these countries.

Figure 1 - Shaded contour plots of age-specific and cumulative cohort fertility rates in 45 countries, 1900-2000





Legend (1):

a1 = Country
a2 = Tile colour denoting region (see Legenda 2)
b = Contour lines for different cumulative cohort fertility rates (CCFRs)
b1 = (thick solid line) CCFR of 2.05 (replacement)
b2 = (thick dashed line) CCFR of 1.80
b3 = (thin solid line) CCFR of 1.50
b4 = (thin dashed line) CCFR of 1.30
c = Shaded plot based on different age-specific fertility rates (ASFRs) – see bar on the right-hand side of figure 1.
d = Year of birth
e = Age in years

Note: Further information including R code can be retrieved from https://github.com/JonMinton/comparative_fertility.
Source: Own computation based on combined data from Human Fertility Database (HFD) and Human Fertility Collection (HFC).

Legend (2): Countries in figure 1 are ranked in descending order by last observed CCFR. Years for which available data span are provided in parentheses. Countries are grouped in regions as follows:

- = *South-Eastern Europe:* Albania (1955-2008), Bosnia and Erzegovina (1950-2014), Bulgaria (1947-2009), Macedonia (1950-2014), Romania (1951-2012).
- = *Northern Europe*: Denmark (1901-2012), Finland (1939-2014), Iceland (1853-2014), Norway (1946-2014), Sweden (1891-2014).
- = *Western Europe:* Austria (1937-2014), Belgium (1939-2010), France (1946-2008), Germany-East (1952-2010), Germany–West (1950-2010), Ireland (1955-2013), Netherlands (1950-2009), Switzerland (1932-2011), UK–England and Wales (1911-2011), UK–Northern Ireland (1974-2014), UK-Scotland (1939-2014).
- = *Non- European Anglophone countries:* Australia (1921-2014), Canada (1921-2011), United States of America (1917-2014), New Zealand (1937-2015).
- = *Central Europe:* Croatia (1950-2014), Czech Republic (1945-2014), Estonia (1959-2014), Hungary (1938-2014), Latvia (1965-2009), Lithuania (1959-2014), Poland (1948-2014), Slovakia (1946-2009), Slovenia (1950-2014).
- = *Asian countries*: Japan (1925-2013), Republic of Korea (1973-2007), Taiwan (1950-2014).
- = *Eastern Europe:* Belarus (1960-2014), Moldova (1961-2014), Russia (1959-2014), Ukraine (1959-2014).
- = *Southern Europe*: Greece (1950-2009), Italy (1952-2014), Portugal (1940-2014), Spain (1940-2014).

References (1):

Lexis, W. (1875). *Einleitung in die Theorie der Bevölkerungsstatistik.* Straβburg: K.J. Trübner.
Minton, J. (2014). Real geographies and virtual landscapes: Exploring the influence n place and space on mortality Lexis surfaces using shaded contour maps. *Spatial and Spatio-temporal Epidemiology, 10*, 49-66.
Minton, J., Vanderbloemen, L., & Dorling, D. (2013). Visualizing Europe's demographic scars with coplots and contour plots. *International Journal of Epidemiology, 42*(4), 1164-1176.

References (2):

Vaupel, J.W., Bradley, A., Gambill, B.A., & Yashin A.I. (1987). Thousands data at a glance: Shaded contour maps of demographic surfaces. Laxemburg: International Institute for Applied Systems Analysis.

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